GRADE 12 DIPLOMA EXAMINATION

Physics 30

June 1992

Alberta
EDUCATION

GRADE 12 DIPLOMA EXAMINATION
PHYSICS 30

DESCRIPTION

Time allotted: 2.5 hours

Total possible marks: 70

This is a **closed-book** examination consisting of **three** parts:

PART A has 42 multiple-choice questions each with a value of one mark.

PART B has seven numerical-response questions each with a value of one mark.

PART C has four written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

GENERAL INSTRUCTIONS

Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.

You are expected to provide your own scientific calculator.

Carefully read the instructions for each part before proceeding.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET.

The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.

JUNE 1992

PART A

INSTRUCTIONS

In this part of the examination, there are 42 multiple-choice questions each with a value of one mark. All numbers used in the questions are to be considered as the result of a measurement.

Read each question carefully and decide which of the choices **best** completes the statement or answers the question. Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice. **Use an HB pencil only**.

Example **Answer Sheet**

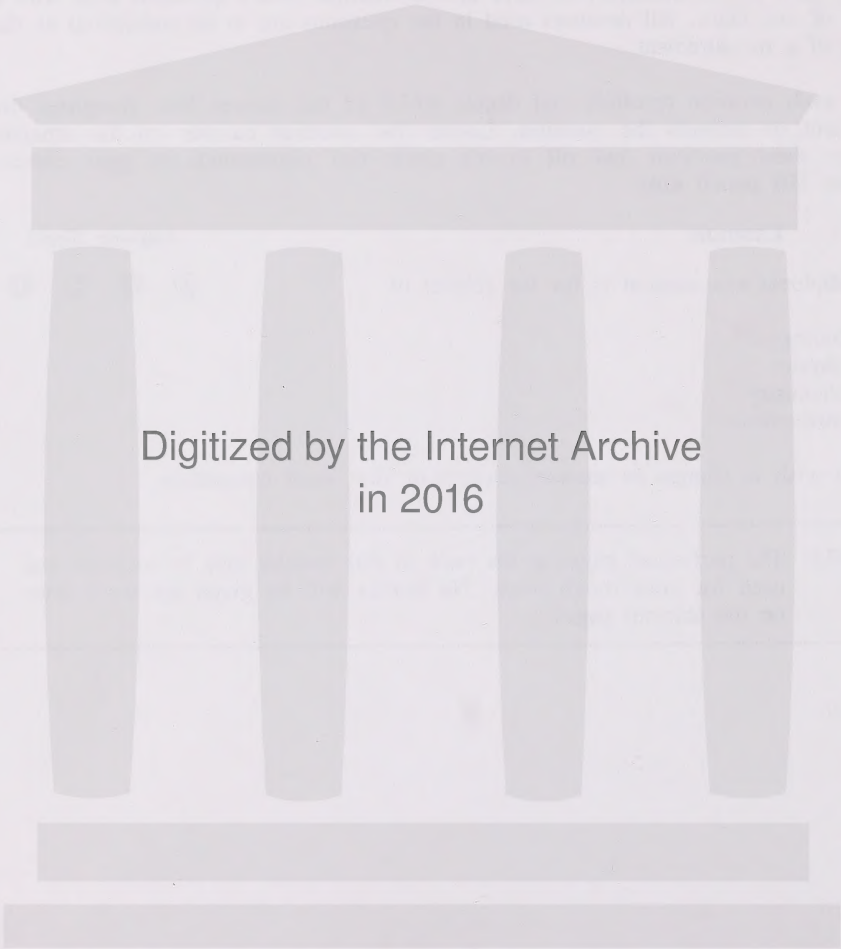
This diploma examination is for the subject of Ⓐ ● Ⓒ Ⓓ

A. biology
B. physics
C. chemistry
D. mathematics

If you wish to change an answer, erase your first mark completely.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER.



1. A ray of light passes through a medium that has a refractive index of 1.2. An angle of refraction of 90° in air will occur when the angle of incidence in the medium is

A. 75°
B. 56°
C. 34°
D. 15°

2. Light of frequency 5.40×10^{14} Hz approaches an air-glass interface at an angle of incidence of 71.0°. The angle of refraction for the light in the glass is 39.0°. The wavelength of the light when it passes through the glass is

A. 3.05×10^{-7} m
B. 3.70×10^{-7} m
C. 5.55×10^{-7} m
D. 8.35×10^{-7} m

Use the following information to answer question 3.

Properties of Light

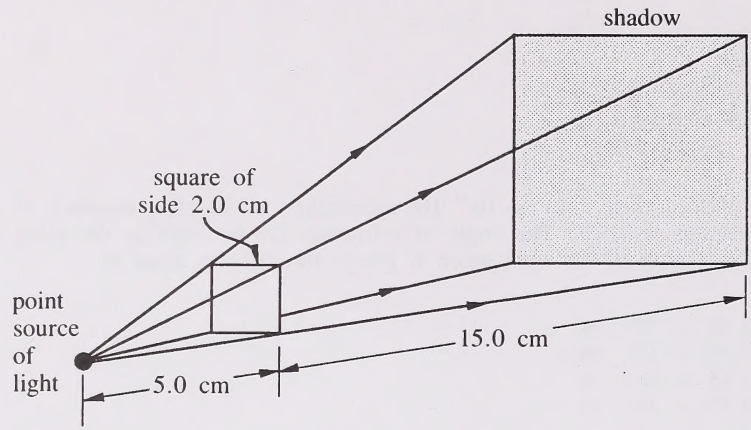
I. Light can be polarized.
II. Light travels in straight lines.
III. Light can produce interference patterns.
IV. When light is reflected, the angle of incidence equals the angle of reflection.
V. Within optically dense materials, total internal reflection occurs for angles of incidence greater than a certain critical angle.

3. The transmission of light through optical fibers depends on properties

A. I, II, and III
B. I, III, and V
C. II, IV, and V
D. III, IV, and V

Use the following information to answer question 4.

Shadow on a Wall



The diagram is **not** drawn to scale.

4. A square of cardboard measuring 2.0 cm a side is held 5.0 cm from a point source of light so that it casts a shadow on a wall 15.0 cm behind the cardboard. If the cardboard is parallel to the wall, the area of the shadow is

A. 6.0 cm^2
B. 12 cm^2
C. 36 cm^2
D. 64 cm^2

Use the following information to answer question 5.

Data Collected During an Experiment Using Filters

Object	Appearance in white light	Spectral analysis of colors reflected
X	yellow	yellow
Y	yellow	orange, yellow, green

5. A filter is a device that allows only a certain color of light to pass. When objects X and Y are viewed through a pure green filter, the expected result is that

A. X will appear black and Y will appear green
B. X will appear black and Y will appear yellow
C. X will appear green and Y will appear yellow
D. X will appear yellow and Y will appear green

---

6. Römer and Huygens were the first scientists whose estimate of light's speed was close to its theoretical value. Part of the process they used in their method involved

A. flashing a light and noting the time it took for a person to react

B. measuring the time it took for light to cross the diameter of Earth's orbit

C. placing two mirrors at an angle and noting the constructive and destructive interference

D. using an eight-sided rotating mirror and calculating the time it took for the light to travel a certain distance and then return

7. The Poisson spot is caused by

A. diffraction and interference
B. reflection and interference
C. reflection only
D. refraction only

8. The second-order image in a diffraction pattern has an angle of deviation of 60.0° from the light source. If the grating has 1.0×10^4 lines/cm, then the wavelength of the light used is

A. 1.0×10^{-6} m
B. 5.0×10^{-7} m
C. 4.3×10^{-7} m
D. 2.5×10^{-7} m

9. Polaroid sunglasses reduce the glare from reflected sunlight. A probable explanation for this observation is that the

A. sunglasses filter out the ultraviolet light

B. sunglasses are oriented at an angle relative to the eye's polarizers

C. refractive index for the polarizers is different from the refractive index for the eye's lens

D. reflected light that is incident on the sunglasses is partially polarized

10. The classical wave theory of light is **weak** in explaining the

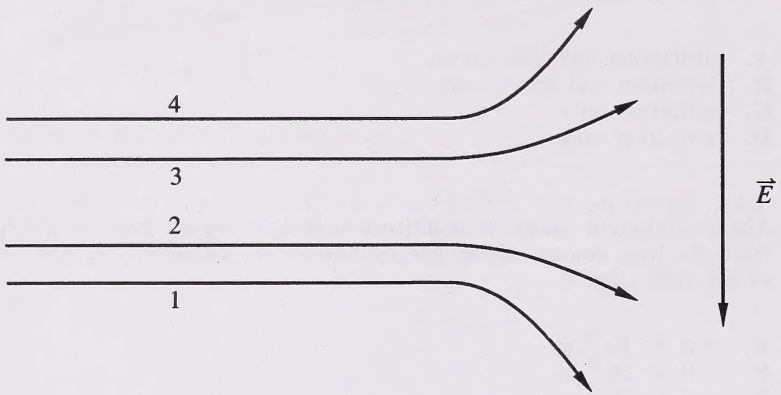
A. refraction of light in water
B. reflection of light from a mirror
C. transmission of light through a vacuum
D. interference of light incident on a double slit

11. A light is observed through two polarizing filters. If one filter is rotated through 180°, the intensity of the light

A. increases only
B. decreases only
C. increases only or decreases only depending upon the initial alignment
D. increases and then decreases or vice versa depending upon the initial alignment

Use the following information to answer question 12.

Paths of Charged Particles in an Electric Field



The masses and speeds of the particles are equal.

12. Which statement is true?

A. The charges on particles 2 and 3 are equal in magnitude and in sign.
B. The charges on particles 3 and 4 are equal in magnitude and in sign.
C. The charges on particles 2 and 3 are equal in magnitude but not in sign.
D. The charges on particles 3 and 4 are equal in magnitude but not in sign.

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13. Two objects can become charged when rubbed together because

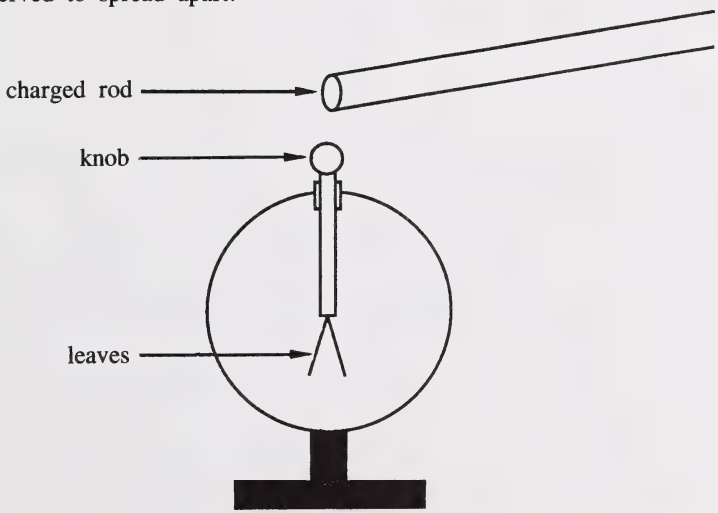
A. like charges repel and unlike charges attract
B. negative charges redistribute but positive charges remain fixed
C. both positive and negative charges redistribute when the objects touch
D. positive charges move from one object to another when the objects touch

14. A 3.5×10^{-6} C charge experiences a force of 0.45 N at a point in space. The intensity of the electric field at that point is

A. 1.6×10^{-6} N/C
B. 7.8×10^{-6} N/C
C. 3.1×10^{4} N/C
D. 1.3×10^{5} N/C

Use the following information to answer question 15.

When a charged rod is close to a neutral electroscope, the leaves of the electroscope are observed to spread apart.



15. While the charged rod is held close to the knob of the electroscope, one can infer that

A. only the leaves have a charge similar to that of the rod
B. only the leaves have a charge opposite to that of the rod
C. both the leaves and the knob have a charge similar to that of the rod
D. both the leaves and the knob have a charge opposite to that of the rod

---

16. Electrons in the picture tube of a color television are accelerated through 25 kV to form a 1.0×10^{-3} A beam. At what rate is energy being delivered to the television screen?

A. 25 W
B. 0.40 W
C. 0.25 W
D. 0.040 W

17. What is the kinetic energy of a particle of mass 1.00×10^{-5} kg travelling at 2.00×10^{-1} m/s?

A. 2.00×10^{-10} eV
B. 2.00×10^{-3} eV
C. 1.25×10^{12} eV
D. 1.25×10^{9} eV

18. If an electron and a proton each accelerate from rest through a potential difference of 1000 volts, they will have the same final

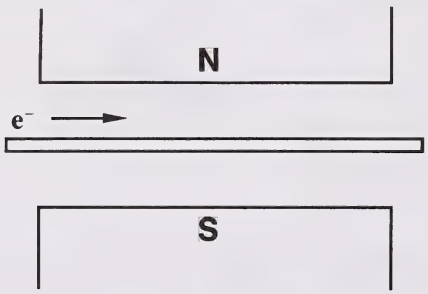
A. speed
B. momentum
C. kinetic energy
D. charge-to-mass ratio

19. An electric current in a conductor produces magnetic lines of force that

A. circle the conductor
B. are directed toward the conductor
C. are directed perpendicularly outward from the conductor
D. surround the conductor and are parallel to the conductor

Use the following information to answer question 20.

A Current-Carrying Wire in an External Magnetic Field



20. The part of the wire in the magnetic field is 10.0 cm long and carries a current of 10.0 A. If the strength of the magnetic field is 0.050 T, then the resulting force on the wire is

A. 0.050 N out of the page
B. 5.0 N out of the page
C. 0.050 N into the page
D. 5.0 N into the page

21. A particle that is not deflected when it passes perpendicularly through a magnetic field is likely to be

A. a proton
B. a neutron
C. an electron
D. an alpha particle

22. What is the radius of curvature of the path of an alpha particle travelling at 1.0×10^{5} m/s perpendicularly into a magnetic field of strength 1.0×10^{-3} T?

A. 0.53 m
B. 1.0 m
C. 2.1 m
D. 4.2 m

23. The most convincing part of the evidence that led Maxwell to conclude that light is a form of electromagnetic radiation was that

A. both electromagnetic waves and light can be reflected
B. both electromagnetic waves and light can be diffracted
C. magnetic fields can change the direction of polarization of light
D. the theoretical speed of electromagnetic waves is close to the measured speed of light

Use the following information to answer question 24.

Statements about Electromagnetic Waves

I. The electromagnetic spectrum covers a wide range of frequencies.

II. Different electromagnetic waves travel at different speeds in a vacuum.

III. The electromagnetic spectrum includes sound waves.

IV. All electromagnetic waves are transverse.

24. The true statements are

A. I and II
B. I and IV
C. II and IV
D. III and IV

25. The first experimental evidence that confirmed the existence of electromagnetic waves was provided by

A. Faraday
B. Maxwell
C. Oersted
D. Hertz

Use the following information to answer question 26.

This paragraph contains a factual error:

Electromagnetic radiation of all wavelengths travels at a speed of 3.00×10^8 m/s in interstellar space. However, when electromagnetic radiation travelling directly toward Earth enters Earth's atmosphere, the waves change speed and are diffracted. The change in speed and the resulting diffraction are caused by a wavelength change when the electromagnetic radiation enters Earth's atmosphere.

26. Which statement below identifies the error in this paragraph?

A. Electromagnetic radiation travels in interstellar space.

B. Electromagnetic radiation changes wavelength when it enters Earth's atmosphere.

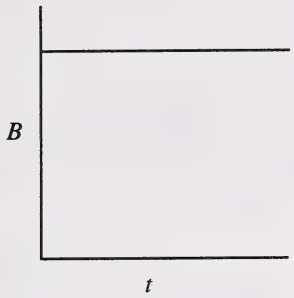
C. All wavelengths of electromagnetic radiation travel at 3.00×10^8 m/s in interstellar space.

D. Diffraction is the result of a change in the speed of the electromagnetic radiation when it enters a medium.

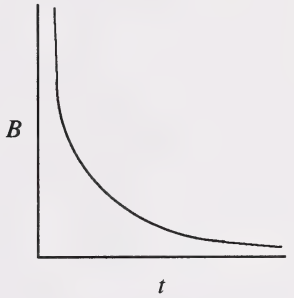
Use the following information to answer question 27.

Magnetic Field Strength as a Function of Time

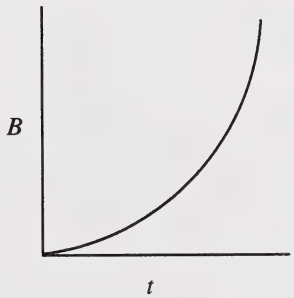
I



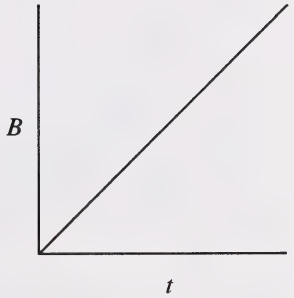
II



III



IV



27. An electric field would **not** be produced by

A. I only
B. IV only
C. I and II
D. III and IV

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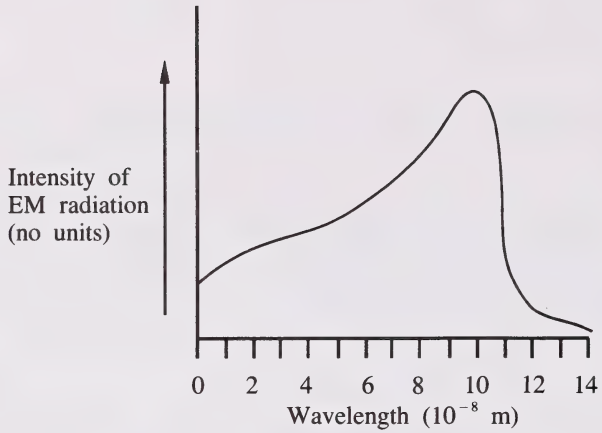
28. What is the period of electromagnetic radiation that has a wavelength of 2.0×10^{2} m?

A. 3.3×10^{-14} s
B. 1.7×10^{-11} s
C. 6.7×10^{-7} s
D. 1.5×10^{-4} s

Use the following information to answer question 29.

Distribution of Electromagnetic Radiation on the Surface of the Planet Sigma



29. Beings on the fictitious planet Sigma have visual receptors that are extremely sensitive to the most prevalent type of electromagnetic radiation on the planet. Based on the graph, these visual receptors may be most sensitive in the frequency range from

A. 2.9×10^{15} Hz to 3.8×10^{15} Hz
B. 4.0×10^{15} Hz to 5.0×10^{15} Hz
C. 6.1×10^{15} Hz to 4.2×10^{16} Hz
D. 7.0×10^{15} Hz to 3.0×10^{16} Hz

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30. A prism is made of a substance that has an index of refraction of 1.6 for **all** forms of electromagnetic radiation. It would be **false** to state that

A. the angle of refraction for red light is the same as the angle of refraction for blue light

B. the critical angle for red light is the same as the critical angle for blue light

C. white light entering the prism will leave as white light

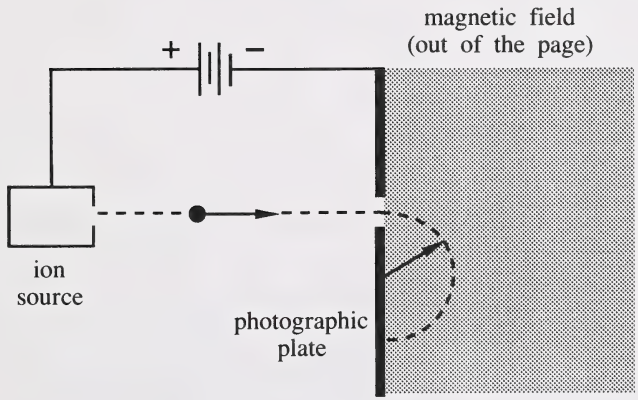
D. red light is slowed in the prism more than blue light is

31. Water can be separated into hydrogen and oxygen by

A. boiling
B. emission
C. induction
D. electrolysis

Use the following information to answer question 32.

Path of an Ion in a Mass Spectrograph



32. Sodium ions are deflected in an arc of radius 0.0800 m. What type of ion travelling at the same speed could be detected at a radius of 0.375 m?

A. Ag^+
B. Cu^+
C. K^+
D. Rb^+

---

33. Dalton chose hydrogen as the unit for relative atomic masses because hydrogen

A. combined readily with most other elements
B. appeared to have the smallest atomic mass
C. could be easily obtained in a pure form
D. appeared to have only one isotope

34. The photoelectric effect provides evidence from which it was inferred that light

A. generates electrons
B. originates in atoms
C. has wave properties
D. has a particle nature

35. A metal surface has a threshold frequency of f_o. If the metal surface is illuminated with radiation of a frequency of $3.5f_o$, then the maximum kinetic energy of emitted photoelectrons is

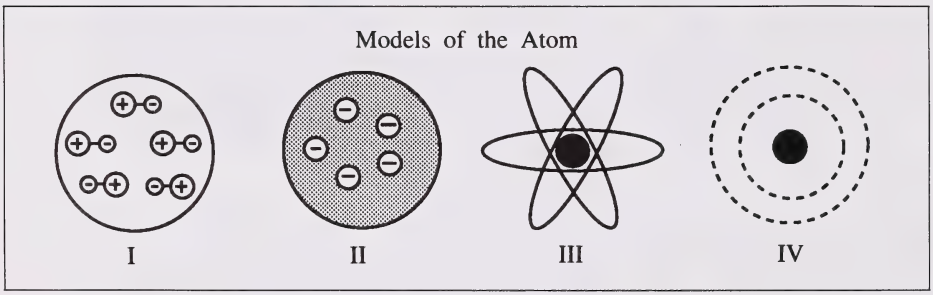
A. $4.5hf_o$

B. $3.5hf_o$

C. $2.5hf_o$

D. $1.0hf_o$

Use the following information to answer question 36.



36. Thomson's model of the atom is best represented by diagram

A. I
B. II
C. III
D. IV

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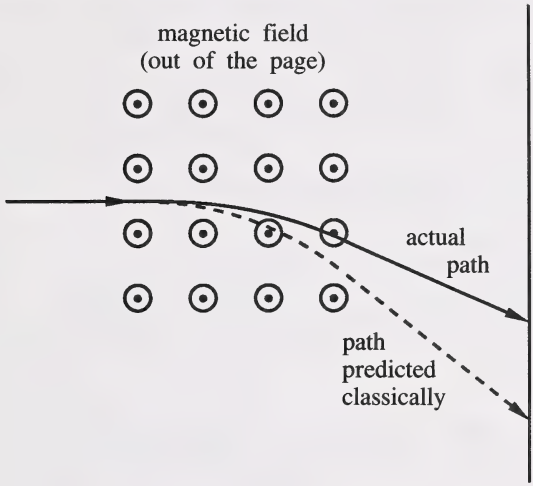
37. A photon of energy 16.4 eV is incident upon an electron of a hydrogen atom in its first energy level. If the photon ionizes the hydrogen atom, what is the kinetic energy of the ejected electron?

A. 2.80 eV
B. 13.6 eV
C. 16.4 eV
D. 30.0 eV

Use the following information to answer question 38.

A very high-speed alpha particle passes through a magnetic field as shown. The actual path travelled has a larger radius than the path predicted by classical physics.



38. The prediction in classical physics represented by the diagram

A. ignores the change in the charge of the alpha particle at high speeds

B. is restricted to cases where the alpha particle moves in a straight line

C. fails to account for the mass increase experienced by the alpha particle

D. is valid when the speed of the alpha particle is greater than the speed of light in a vacuum

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39. As the speed of an electron increases, its charge-to-mass ratio will

A. increase because its charge decreases
B. decrease because its charge increases
C. increase because its mass increases
D. decrease because its mass increases

40. A photon of wavelength 7.86×10^{-11} m strikes an electron at rest and imparts 1.47×10^{-16} J of energy to the electron. The wavelength of the departing photon is

A. 1.3×10^{-9} m
B. 8.3×10^{-11} m
C. 7.4×10^{-11} m
D. 2.4×10^{-15} m

41. The momentum of a photon is

A. directly proportional to its frequency
B. inversely proportional to its frequency
C. directly proportional to the square of its frequency
D. inversely proportional to the square of its frequency

42. If the uncertainty in the momentum of an atomic particle is 5×10^{-25} kg•m/s, the minimum theoretical uncertainty in the position of the particle will be

A. 10^{-25} m
B. 10^{-19} m
C. 10^{-10} m
D. 10^{-1} m

YOU HAVE NOW COMPLETED PART A. PROCEED DIRECTLY TO PART B.

PART B

INSTRUCTIONS

In this part of the examination, there are seven numerical-response questions each with a value of one mark. All numbers used in the questions are to be considered as the result of a measurement.

Read each question carefully.

Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.

Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.

Use an HB pencil only.

Sample Questions and Solutions

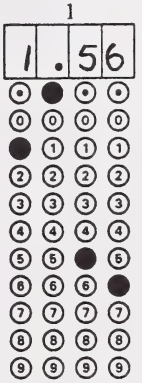
Answer Sheet

1. If the angle of incidence in air is 47.6° and the angle of refraction is 28.3°, the index of refraction is _____ .
(Round and record your answer to **three** digits.)

$$n = \frac{\sin \theta_1}{\sin \theta_2}$$

$$n = \frac{\sin 47.6°}{\sin 28.3°} = 1.5576328$$

Record 1.56



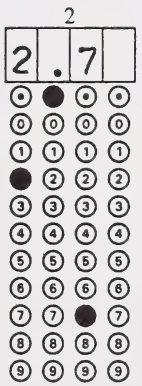
2. A microwave of wavelength 11.0 cm has a frequency of $b \times 10^9$ Hz. The value of b is _____ .
(Round and record your answer to **two** digits.)

$$f = c/\lambda$$

$$= (3.00 \times 10^8 \text{ m/s})/(0.11 \text{ m})$$

$$f = 2.727... \times 10^9 \text{ Hz}$$

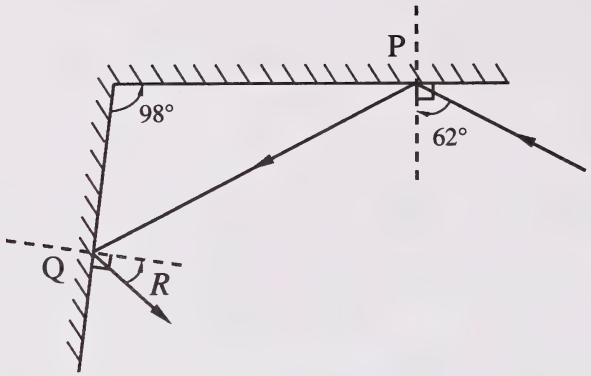
Record 2.7



If you wish to change an answer, erase **all** traces of your first answer.

START PART B IMMEDIATELY.

Use the following information to answer question 1.



A light wave is reflected at P and again at Q. The diagram is not drawn to scale.

1. The calculated value of angle R is _____ degrees.
(Round and record your answer to **two** digits.)

RECORD THE ANSWER ON THE ANSWER SHEET

Use the following information to answer question 2.

A charged sphere, located in the space between two flat parallel plates connected to a battery, experiences an electrical force of 3.32×10^{-3} N.

2. The plates are kept at the original separation. If the charge on the sphere is reduced to exactly one-half and the potential difference between the plates is exactly tripled, then the force on the charged sphere will be $\boldsymbol{b} \times 10^{-3}$ N. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to **three** digits.)

RECORD THE ANSWER ON THE ANSWER SHEET

3. A household circuit that can maintain a maximum current of 15.0 A with a potential difference of 120 V runs **three** 75.0 W light bulbs and a 7.50×10^2 W toaster. The **maximum** number of 60.0 W light bulbs that can be added to this circuit without overloading it is _____ bulbs.

RECORD THE ANSWER ON THE ANSWER SHEET

4. A microwave is incident on a prism of transparent plastic that has an index of refraction of 1.42. When the microwave passes through the prism, its speed is $b \times 10^8$ m/s. The value of b is _____ .
(Round and record your answer to **three** digits.)

RECORD THE ANSWER ON THE ANSWER SHEET

5. The distance from the Earth to the moon is 3.84×10^5 km. Using infra-red radiation, the time required for a signal to go to the moon and to return is _____ s.
(Round and record your answer to **three** digits.)

RECORD THE ANSWER ON THE ANSWER SHEET

6. The energy of a photon of blue light, expressed in scientific notation, is $b \times 10^{-w}$ J. If the wavelength of the light is 4.5×10^{-7} m, then the magnitude of the exponent w is _____ .

RECORD THE ANSWER ON THE ANSWER SHEET

7. A rocket travelling at a speed of $0.395c$ has a relativistic mass of 9.12×10^{4} kg. The rest mass of the rocket, expressed in scientific notation, is $b \times 10^{w}$ kg. The value of b is _____ .
(Round and record your answer to **three** digits.)

RECORD THE ANSWER ON THE ANSWER SHEET

YOU HAVE NOW COMPLETED PART B. PROCEED DIRECTLY TO PART C.

PART C

INSTRUCTIONS

In this part of the examination, there are four written-response questions for a total of 21 marks. All numbers used in the questions are to be considered as the result of a measurement.

Read each question carefully.

Write your answers in the examination booklet as neatly as possible.

For full marks, answers **must show all** pertinent explanations, calculations, and formulas.

All numerical answers must be given correct to the appropriate number of significant digits.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

START PART C IMMEDIATELY.

FOR DEPARTMENT USE ONLY

(6 marks)

1. An ion with a charge of $2e$ and a mass of 8.63×10^{-26} kg is accelerated from rest using a high voltage source. The ion enters a magnetic field perpendicularly, where it experiences a centripetal force of 1.20×10^{-13} N and travels in an orbit of radius 0.200 m.

   a. Find the nonrelativistic speed of the ion.

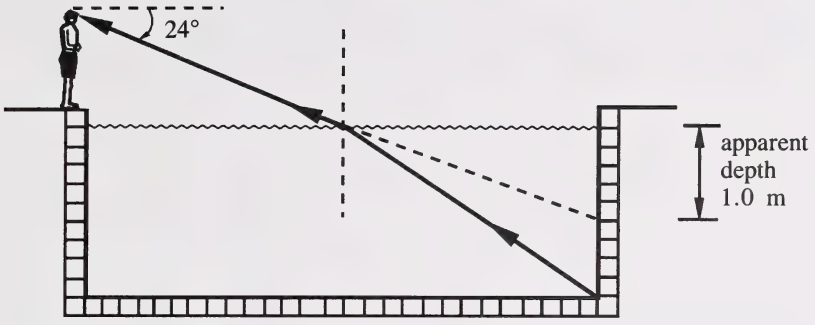
   b. Find the strength of the magnetic field. (Note: If you are unable to find the speed in part a, use the hypothetical value of 5.10×10^{5} m/s.)

   c. Find the accelerating voltage, assuming that the speed of the ion is nonrelativistic.

FOR DEPARTMENT USE ONLY

(4 marks)

Use the following information to answer question 2.



A swimmer standing on one side of a swimming pool looks down at an angle of depression of 24° and sees the bottom of the pool at the opposite side. To the swimmer, the pool appears to be 1.0 m deep.

The diagram is **not** drawn to scale.

2. If the index of refraction of water is 1.33, calculate the actual depth of the pool.

FOR DEPARTMENT USE ONLY

(6 marks)

Use the following information to answer question 3.

A power supply is connected to a particular light-emitting diode (LED). The LED emits light of wavelength 6.36×10^{-7} m. The voltage is varied and the current for each voltage is recorded. The results are given in the table:

Voltage V (V)	Current I (10^{-3} A)
3.0	1.6
4.0	3.0
6.0	6.0
8.0	8.5
9.0	10.0
10.0	11.5

For this particular LED, the voltage V and the current I are related by the formula

$$V = ZI + \frac{hc}{q_e\lambda}$$

where Z is the ohmic resistance of the LED and q_e is the electron charge.

3. a. Plot a graph of voltage as a function of current, with the current on the horizontal axis.

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You may solve the rest of the question in the order that you find easiest.

b. Use the appropriate intercept, or any other suitable means, to estimate the value of Planck's constant from the experiment.

c. Use an appropriate averaging technique to find the best estimate of the ohmic resistance Z of the LED.

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(5 marks)

4. Electrons can exhibit **observable** wave properties. No corresponding observations have been made for automobiles. Explain why experiments can be done to observe the wave nature of electrons travelling at 5.0×10^6 m/s. Next, explain why experiments cannot be done to observe the wave nature of an automobile of mass 1.0×10^3 kg travelling at 10.0 m/s. Support your explanations by using calculations based on de Broglie's wave equation. Then, outline any relevant experiment(s) supporting these explanations.

(Calculations alone, with no supporting explanations, are worth a possible maximum of **two** marks.)

Explanations:

Calculations:

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Outline of relevant experiment(s):

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

TEAR-OUT PAGE

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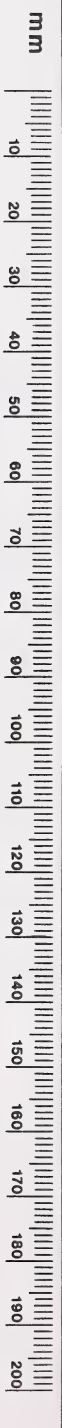

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